Chapter 5

People's Republic of China Country Report

Yu Hao
and
Zong-Yong Zhang
Beijing Institute of Technology (BIT), China

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CHAPTER 5

People's Republic of China Country Report

YU HAO, ZONG-YONG ZHANG
Center for Energy and Environmental Policy Research (CEEP),
Beijing Institute of Technology (BIT), China

1. Background

1.1. Natural Condition and History

The People's Republic of China has a land area of 9.6 million square kilometres and is situated in eastern Asia on the western shore of the Pacific Ocean. China's continental coastline extends for about 18,000 kilometres, and its vast sea surface has more than 5,000 islands. Due to its size, China's climate is very diverse, with temperatures ranging from 48ºC in the northwest during summer to -40ºC in the far north in winter.

China has more than 5,000 years of history and is one of five countries with a great ancient civilization. The People's Republic of China was founded on 1 October 1949. Today, China is implementing reforms and opening up its economy, and has established a socialist market economy, thereby charting a course for socialist modernisation with Chinese characteristics.

1.2. Economy and Population

China's gross domestic product (GDP) in 2014 was around US$6.92 trillion, which translates into a per capita income of around US$5,055 (in 2005 US$ terms).[1] China is currently the world's most populous country. It had a population of about 1.37 billion in 2014.[2] To mitigate population growth, China has implemented a family planning policy since the 1970s. China has been experiencing a fast urbanisation process at an annual growth rate of approximately 1 percent since 1978 when China's reforms and opening up started. At the end of 2013, around 53.7 percent of the population was living in urban areas.

1.3. Energy Situation

In terms of energy resources, China is endowed with coal, oil, and gas reserves and tremendous hydropower potential. China is the world's largest coal producer and has the third largest coal reserves, with reserves of 236.3 billion tonnes in 2014. In 2013, China produced 2.57 billion tonnes of raw coal. The country is still a major crude oil producer,

[1] The source of the GDP data is the China National Bureau of Statistics (NBS). The author calculated the constant 2005 value using GDP Deflator and exchange rate in 2005.
[2] China National Bureau of Statistics.

with output of 302.6 million tonnes of crude oil in 2013. However, driven by very fast increases in China's oil demand, it became an oil importer in the 1990s. In 2014, net imports of oil reached 290 million, with a growth rate of 8.2 percent. China is also a large producer and exporter of energy-intensive items. In 2014, it produced 1.13 billion tonnes of finished steel and 2.48 billion tonnes of cement, and exported 0.94 billion tonnes of finished steel.

China's per-capita energy reserve is considerably lower than the world average. The per-capita average of both coal and hydropower resources is at present only about 50 percent of the world average, whereas the per-capita average of both oil and natural gas reserves is only about one-fifteenth of the world average. The per-capita average of arable land is less than 30 percent of the world average, which hinders the development of biomass energy.

In 1990, coal accounted for 60.6 percent of primary energy consumption, oil made up 13.6 percent, natural gas just below 1.5 percent, and hydro 1.3 percent. In 2014, coal was still a major fuel, with a higher share of about 66.0 percent.[3] As for the share of other energy sources, oil increased from 1990 levels to 17.1 percent, and gas and electricity reached 5.7 percent and 9.8 percent, respectively. Primary energy consumption in China increased at an average annual rate of around 5.6 percent, from 870.7 Mtoe in 1990 to 2,982 Mtoe in 2014. Energy intensity (primary energy demand per unit of GDP) declined from 1,656 tonnes of oil equivalent per million US$ (toe/million US$) in 1990 to 272.9 toe/million US$ in 2013.[4]

Final energy consumption in China increased at a lower annual average rate of 4.4 percent from 664.2 Mtoe in 1990 to 2,115.2 Mtoe in 2014. Coal accounted for 47.9 percent of final energy consumption in 1990 and 43.1 percent in 2014. In 1990, oil accounted for 12.7 percent of total final energy consumption. Oil consumption has increased rapidly at 7.6 percent per year between 1990 and 2014, leading to a significant increase in its share, to 23.3 percent, in 2014. Electricity consumption also increased markedly, with growth of 11.5 percent between 1990 and 2014, which was higher than any of the other final energy sources. The share of electricity in final energy consumption increased from 5.9 percent in 1990 to 25.2 percent in 2014.[5]

Industry is the major energy-consuming sector in China, followed by the residential and commercial sectors (the 'Others' sector). The share of industry consumption increased from 36.7 percent in 1990 to 47.6 percent in 2012, whereas the share of energy consumption in 'others' declined from 51.8 percent in 1990 to 30.4 percent in 2012, because of faster growth in the industry and transport sectors.

In China, coal-fired power generation accounted for around 71.3 percent of total electricity generation in 1990. By 2014, this share had increased to 74.9 percent. The share of hydro was 20.4 percent in 1990, but declined to 18.8 percent in 2014. Gas and oil, collectively, accounted for about 1.5 percent of total generation in 2014 and the share of nuclear power increased to about 2.3 percent in 2014.[6]

The Chinese government is pushing for the development of a modern energy

[3] Ibid.
[4] Calculate by the author based on NBS data.
[5] China National Energy Administration (2014), *Handbook of Energy Data Analysis.*
[6] Ibid.

industry. The government takes resource conservation and environmental protection as two basic state policies, giving prominence to building a resource-conserving and environment-friendly society in the course of its industrialisation and modernisation.

2. Modelling Assumptions

2.1. Population and Gross Domestic Product

The model results for China were developed by the Institute of Energy Economics, Japan. China's population increased from 1.135 billion in 1990 to 1.351 billion in 2012. Over the projection period, China's population growth is assumed to slow down as a result of the one child policy. China's population is assumed to increase at an average rate of 0.2 percent per year and reach 1.421 billion by 2035.

China's economy grew at an average annual rate of 10.3 percent from US$526 billion in 1990 to about US$4.52 trillion in 2012 (in 2005 US$ terms). In this study, GDP is assumed to grow at a slower rate of 6.8 percent per year from 2012 to 2020, 4.2 percent per year from 2020 to 2035, and 5.1 percent per year from 2012 to 2035. It is calculated to reach US$14.24 trillion by 2035. Given the GDP and population assumptions, GDP per capita in China is projected to increase from around US$3,349 per person in 2012 to US$10,000 per person in 2035.

2.2. Energy and Climate Change Policies

Although China is still a developing country and has a GDP per capita less than one-seventh of that of the United States (according to nominal exchange rate) in 2014, the government has set aggressive goals on energy intensity reduction and addressing climate change issues.

According to the official governmental source, in the last five years, China has achieved significant energy conservation and remarkable progress in environmental protection. In 2013, China's CO_2 emissions per unit of GDP dropped by 4.3 percent compared with the 2012 level. By the end of 2015, output of China's energy saving and environmental protection industry is expected to reach US$725.8 billion. China's current capacity in hydropower, wind power, and plantation areas all rank first in the world, which has made a positive contribution to addressing the problem of global climate change. After the evaluation in 2014, China eliminated obsolete production capacity in the following industries: steel production, 31.1 million tonnes; cement (clinker and mill), 81 million tonnes; plate glass, 37.6 million weight cases. By the end of 2014, the share of thermal power units was 67.3 percent, a year-on-year growth of 5.9 percent.

To develop non-fossil fuel, China continues to increase investment in renewable energy. It invested US$15.6 billion in hydropower stations, US$9.2 billion in nuclear power plants, and US$16.1 billion in wind power in 2014. By the end of 2013, power generation capacity had reached 1,257 GW – the capacity of hydropower, which ranked first globally, reached 280 GW, registering a year-on-year growth of 12.4 percent; nuclear power plants, 14.66 GW; on-grid wind power capacity, which was the largest in the world, amounted to 76.52 GW, increasing 24.6 percent year-on-year; on-grid solar power reached 15.89 GW, growing 366 percent from a year earlier. The installed electricity capacity of non-fossil fuel, including, hydro, nuclear, wind, and solar energies, in 2014 took up 32.8 percent of the whole, 6.2 percentage points higher than the 2010 figure. The electricity generated from

non-fossil fuel accounted for 25.1 percent of total on-grid electricity in 2014.

In China's Outline of the 12th Five-Year Plan (2012–2015) for National Economic and Social Development, it is stipulated that by 2015 energy consumption per unit of GDP will drop by 16 percent from 2010. To achieve this goal, the government has already implemented administrative measures, market based measures, and legal measures to promote energy conservation, and it will continue to implement new policies. Energy intensity reduction goals will be assigned to provincial governments and progress will be announced publicly every year. In addition to energy intensity targets, controlling total energy consumption has been proposed.

The development of renewable energy has also been accelerated. The People's Congress of China passed the Renewable Energy Development Law of China in 2005 to support renewable energy development in the country. The government also announced the target of increasing the share of non-fossil energy to about 15 percent by 2020 (measured in coal-equivalent). Subsidisation policies have also been developed to encourage development of wind power, solar photovoltaic, and biomass.

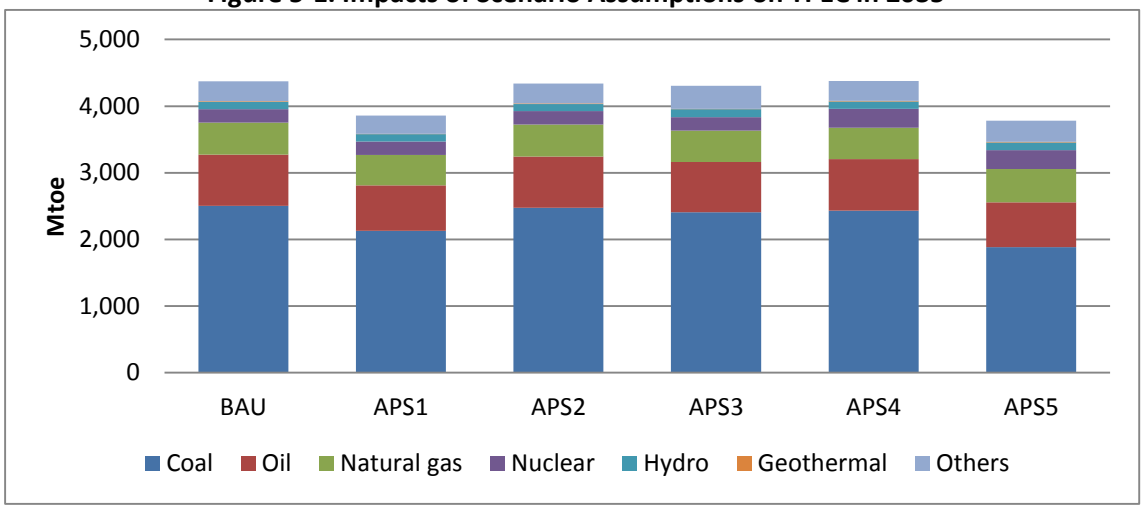
China announced its goal of reducing CO_2 emissions per GDP (carbon intensity) by 40–45 percent from the 2005 level by 2020. To meet the target, China will implement ambitious energy efficiency and fuel switching policies. Moreover, the government has announced its goal of cultivating 40 million hectares of forested land to mitigate greenhouse gas (GHG) emissions.

In our 2014 scenario analyses, we have set five APS scenarios, which are listed as APS1–5 and the meanings of these scenarios are as follows: APS1 – energy efficiency and conservation (EEC) in final consumptions sector; APS2 – EEC in thermal efficiency in coal, oil and gas fired power generations; APS3 – Increase of hydro, geothermal and NRE; APS4 – Increase of nuclear; APS5 – Implement all of the APS1 to APS4. If not specifically declared, all results that we show in this chapter under APS refer to APS5.

3. Outlook Results

As mentioned above, the assumptions in the APS were analysed separately to determine the individual impacts of each assumption in APS1, APS2, APS3, APS4, and the combination of all these assumptions. Figure 5-1 shows the changes in total primary energy consumption (TPEC) in all the scenarios.

Figure 5-1. Impacts of Scenario Assumptions on TPEC in 2035



TPEC = total primary energy consumption; BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

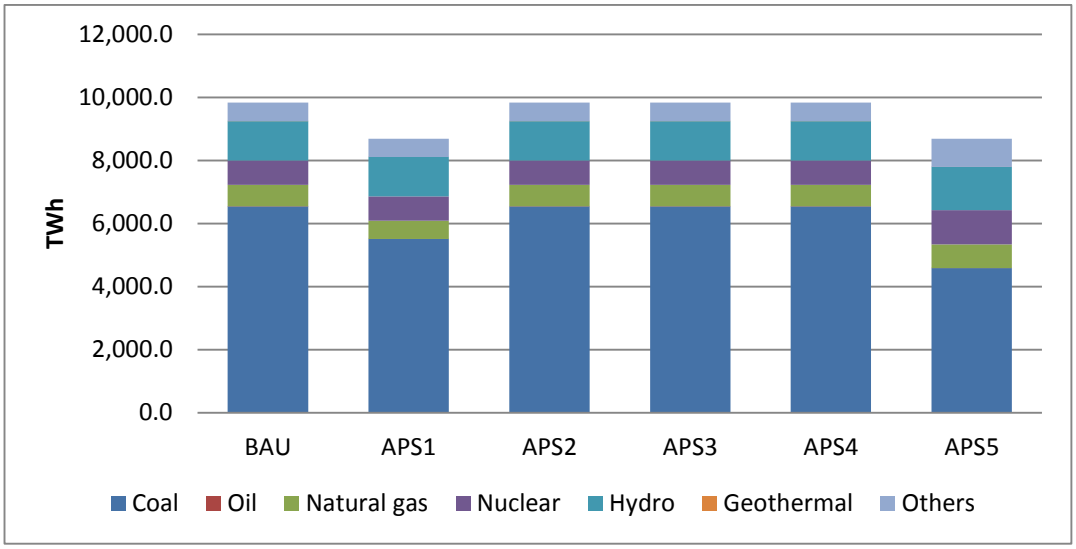
In Figure 5-1 above, APS1 and APS5 have the largest reduction in total primary energy consumption due to the energy efficiency assumptions on the demand-side. Energy efficiency assumptions in APS1 could reduce total primary energy consumption in the Business-as-Usual (BAU) scenario by as much as 513.0 Mtoe or 11.7 percent in 2035.

APS2, which assumes higher efficiency in thermal electricity generation, has a lower impact than APS1. This is due to the assumption that only the newly constructed power plants will have higher efficiency. It is expected that existing power plants will continue to operate until the end of their lifetimes. This is why only 32.3 Mtoe or 0.8 percent of total primary energy consumption is saved under the BAU scenario in 2035.

APS3 assumes higher penetration of renewable energy in electricity generation and higher consumption of biofuels in the transportation sector. Like APS2, there is only a 65.2 Mtoe reduction in total primary energy consumption in BAU in 2035. Although hydropower, solar energy, and wind energy are assumed to have 100 percent thermal efficiency when converted to primary energy, the contributions of these energy sources were dwarfed by the contributions of biomass and geothermal energy, which have lower thermal efficiencies than the fossil-fired electricity generation that were replaced in this scenario. However, a sizeable reduction in CO_2 emission is expected under this scenario.

APS4 assumes a higher contribution of nuclear energy to power generation. There is a small increase of 4.4 Mtoe in total primary energy consumption in this scenario compared with the BAU scenario in 2035. This is due to the lower thermal efficiency of nuclear power generation (33 percent) compared with new coal and natural gas-fired power plants. However, the shift to nuclear achieves a greater carbon emissions reduction.

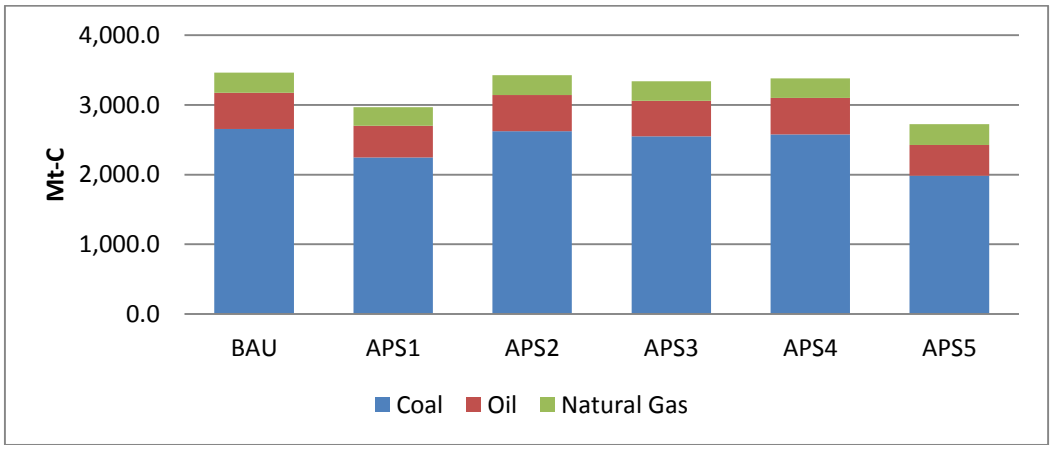
Figure 5-2. Electricity Generation in 2035 in All Scenarios



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

Figure 5-2 shows total electricity generation in East Asia Summit Region (EAS) in 2035 under all scenarios. In APS1, due to lower electricity demand, the shares of fossil-fired electricity generation were lower than in the BAU scenario. In APS2, the shares are the same as those for BAU. In APS5, fossil energy-based generation could be reduced by as much as 26.2 percent.

Figure 5-3. CO_2 Emissions in 2035 in All Scenarios



Source: Author's calculation.

In terms of CO_2 emissions reduction, as shown in Figure 5-3, the energy efficiency assumption in APS1 could reduce emissions in the BAU scenario by 14.2 percent in 2035. In APS2, the installation of more efficient new power plants allows a reduction in emissions of 1.0 percent. Higher contributions from renewable energy in APS3 could reduce emissions by 3.6 percent, and higher contribution from nuclear energy in APS4 could result in an emission reduction of 2.3 percent. All these assumptions combined, as in APS5, could reduce BAU CO_2 emissions by 21.4 percent in 2035.

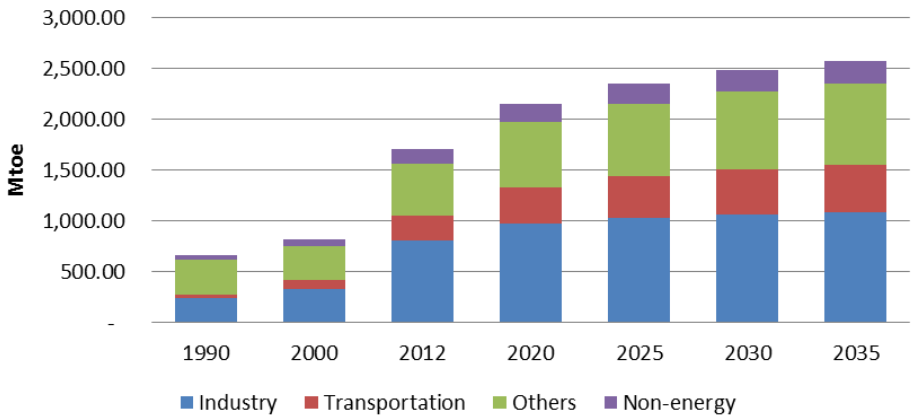
3.1. Total Final Energy Demand

Between 2012 and 2035, growth in China's final energy demand is projected to slow, reflecting lower projected economic and population growth.

Business-as-Usual (BAU) Scenario

Final energy consumption is projected to increase at an average rate of 1.8 percent per year between 2012 and 2035. Transportation sector consumption is projected to see the fastest growth, increasing by 3.0 percent a year, followed by the non-energy sector at 2.3 percent per year. Energy consumption in the industry sector is projected to grow at an average annual rate of 1.3 percent. Figure 5-4 shows China's final energy consumption by sector under the BAU scenario.

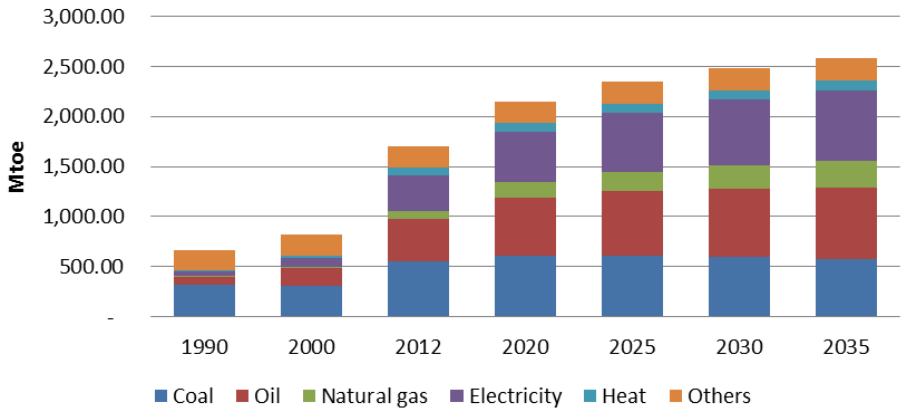
Figure 5-4. Final Energy Consumption by Sector in BAU



BAU = Business-as-Usual.
Source: Author's calculation.

Amongst energy sources, natural gas consumption in the BAU scenario is projected to exhibit the fastest growth, increasing by 5.4 percent per year, from 80.7 Mtoe in 2012 to 272.3 Mtoe in 2035. Although coal still accounts for a large share of total final energy consumption, it is projected to grow at a lower rate, of 0.1 percent per year, reaching 577.0 Mtoe in 2035, compared with a 2.6 percent average annual growth rate over last two decades. Consumption of electricity and heat are projected to increase at average annual rates of 3.0 percent and 1.4 percent, respectively, over the same period, reaching 701.0 Mtoe and 96.5 Mtoe in 2035. Oil is projected to grow by 2.3 percent annually, to around 710.0 Mtoe in 2035. Figure 5-5 shows China's final energy consumption by fuel type under the BAU scenario.

Figure 5-5. Final Energy Consumption by Fuel in BAU

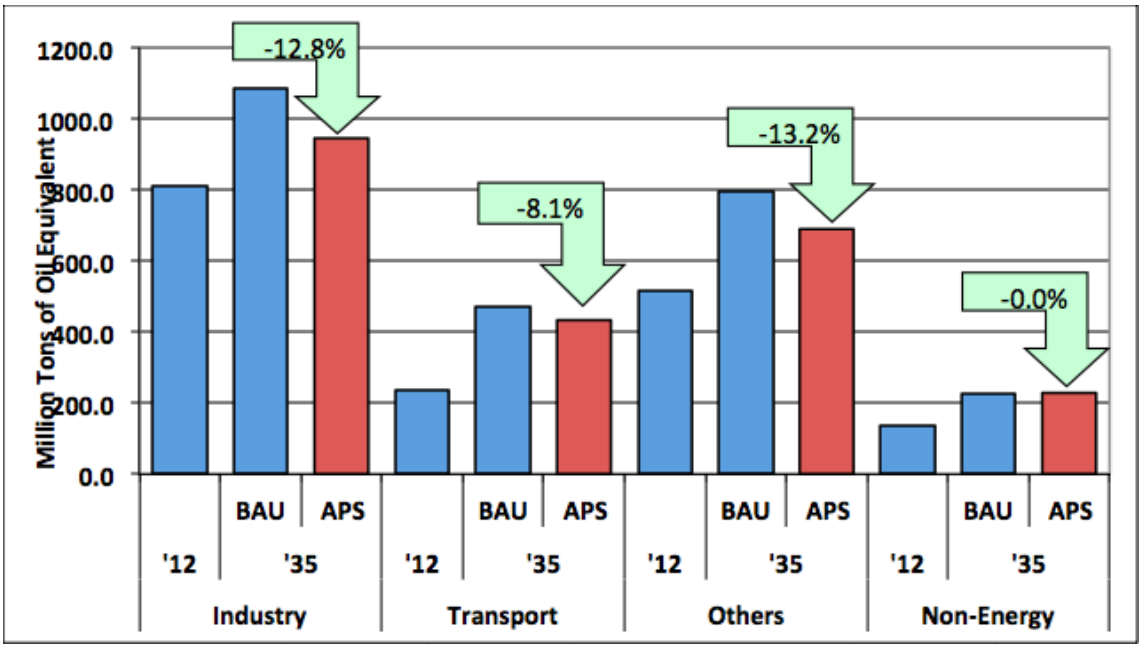


BAU = Business-as-Usual
Source: Author's calculation.

Alternative Policy Scenario (APS)

In the APS, final energy consumption is projected to increase by 1.3 percent per year, from 1,701.9 Mtoe in 2012 to 2,295.7 Mtoe in 2035, as a result of energy efficiency and conservation programmes, as well as further adoption of clean energy technologies. An improvement in end-use technologies and the introduction of energy management systems is expected to contribute to slower energy growth in all sectors, particularly in the commercial, residential, and transportation sectors. Figure 5-6 shows final energy consumption in China in 2012 and 2035 in both the BAU scenario and APS.

Figure 5-6. Final Energy Consumption: BAU and APS



BAU = Business-as-Usual.
Source: Author's calculation.

3.2. Primary Energy Consumption

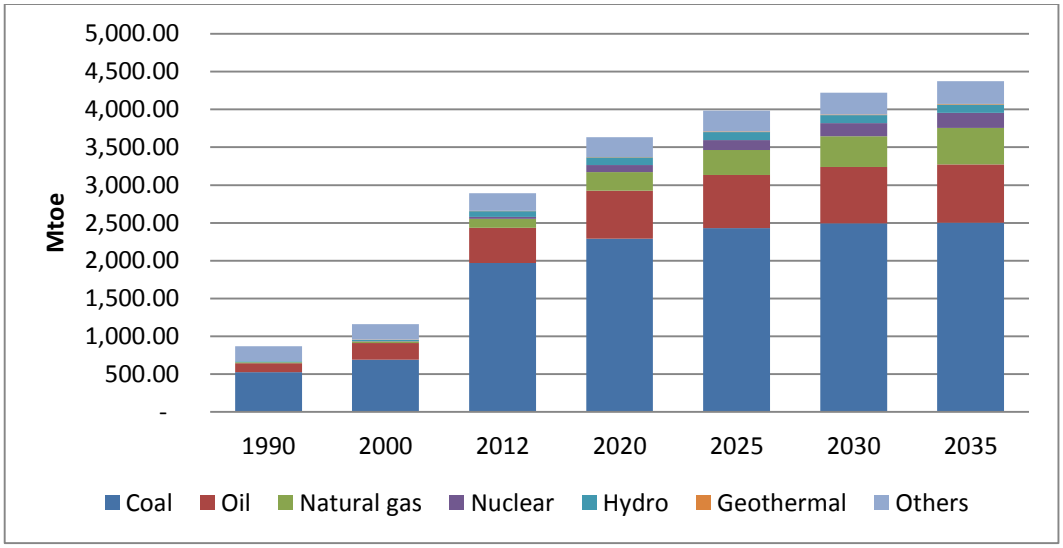
Primary energy consumption in China is projected to grow at a slower pace than in the past decades. It is also expected that growth in primary energy demand will be slightly slower than final energy consumption, because of improved efficiency in the energy transformation sector.

Business-as-Usual Scenario

In the BAU scenario, China's primary energy consumption is projected to increase at an annual average rate of 1.8 percent to 4,372.1 Mtoe in 2035. Coal will still constitute the largest share in total primary energy consumption, but its growth is expected to be slower, increasing by 1.0 percent per year. Consequently, the share of coal in total primary energy is projected to decline from 68.0 percent in 2012 to 57.3 percent in 2035.

Biofuels is projected to exhibit the fastest growth between 2012 and 2035, increasing at an annual average rate of 12.3 percent, followed by nuclear energy at 9.4 percent. Oil and hydro are projected to grow at lower rates of 2.2 and 1.6 percent per year, respectively. The share of natural gas is projected to increase from 4.2 percent in 2012 to 11.0 percent in 2035, and the share of nuclear will increase from 0.9 percent to 4.6 percent. The share of oil is projected to increase from 16.0 percent in 2012 to 17.6 percent in 2035 and hydro is projected to decline from 2.6 percent in 2012 to 2.5 percent in 2035. Figure 5-7 shows China's primary energy consumption by energy type under the BAU scenario.

Figure 5-7. Primary Energy Consumption by Energy, BAU

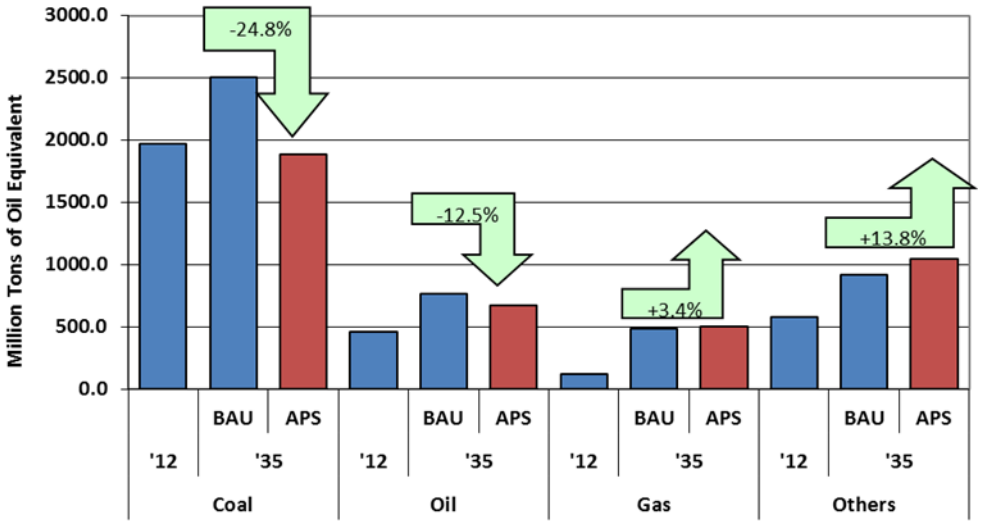


BAU = Business-as-Usual.
Source: Author's calculation.

Alternative Policy Scenario

In the APS, primary energy consumption is projected to increase by 1.2 percent per year between 2012 and 2035. By 2035, primary energy consumption is projected to have reached 3,782.0 Mtoe. The growth in primary energy consumption is projected to be slower under the APS than under the BAU scenario (Figure 5-8). Coal is projected to decline by 0.2 percent per year, and oil is projected to increase by 1.6 percent per year and natural gas by 6.4 percent per year. For nuclear, the annual average growth rate will be higher than the BAU, increasing by 11.1 percent per year between 2012 and 2035. The growth rate of hydro in the APS is expected to be higher than the BAU, increasing by 2.0 percent per year. Mitigated consumption under the APS is mainly achieved through energy efficiency and conservation measures on the demand side.

Figure 5-8. Primary Energy Demand by Source, BAU and APS



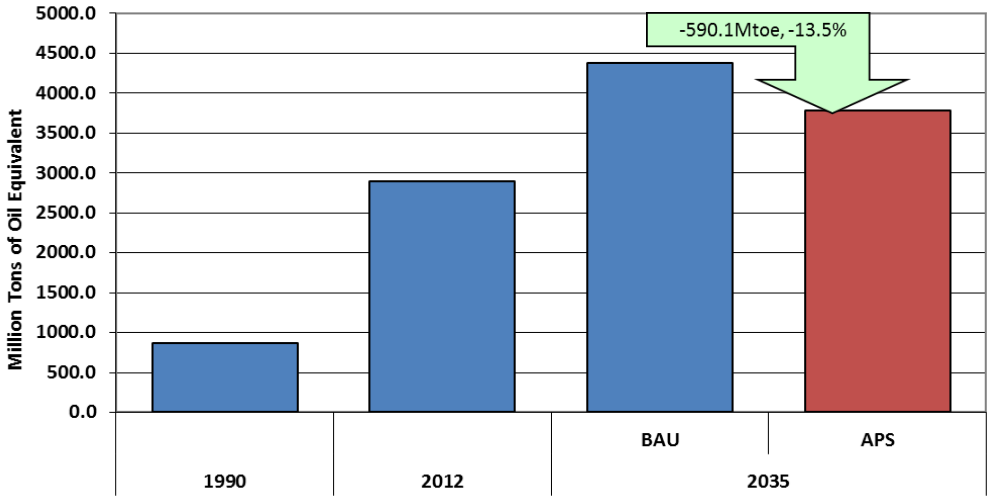
BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

3.3. Projected Energy Savings

It is estimated that the implementation of energy efficiency and conservation goals and action plans in China could reduce primary energy demand in 2035 by about 590.1 Mtoe under the APS, relative to the BAU scenario. In other words, in the APS, China's primary energy demand is around 13.5 percent lower than under the BAU scenario (see Figure 5-9).

In terms of final energy consumption, there is an estimated saving of 139.1 Mtoe in the industry sector, 38.4 Mtoe in the transportation sector, and 104.6 Mtoe in the 'others' sector in 2035 under the APS, relative to the BAU scenario.

Figure 5-9. Total Primary Energy Demand, BAU and APS



BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

3.4. CO_2 Emissions from Energy Consumption

CO_2 emissions from energy consumption are projected to increase by 1.5 percent per year from 2,472.8 Mt-C in 2012 to 3,461.5 Mt-C in 2035 under the BAU scenario. This annual growth rate is lower than that for primary energy demand (1.8 percent) over the same period, indicating a reduction in the emissions intensity of the Chinese economy.

In the APS, the annual increase in CO_2 emissions between 2012 and 2035 is projected to be 0.4 percent. This rate is also lower than the average annual growth rate in primary energy demand over the same period. The difference between the APS and the BAU CO_2 emissions growth rates indicates that the energy saving goals and action plans of China are effective in reducing CO_2 emissions (Figure 5-10).

3.5. Power Generation

Power generation in China is projected to grow more slowly between 2012 and 2035 than in the last decade.

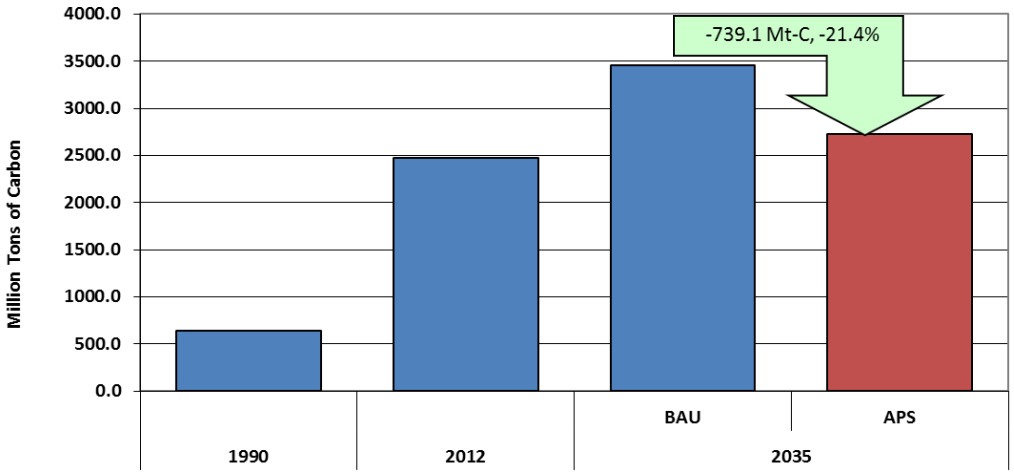
Business-as-Usual (BAU) Scenario

In the BAU scenario, power generation in China is projected to grow at 3.0 percent per year on average from 4,984.8 TWh in 2012 to 9,842.1 TWh in 2035 (Figure 5-11).

The share of coal-fired power under BAU is projected to experience a decreasing trend, from 75.9 percent in 2012 to 66.5 percent in 2035. Conversely, as the cleaner forms of generation, the share of natural gas-fired and nuclear power are both projected to grow from 1.7 and 2.0 percent in 2012 to 6.9 percent and 7.9 percent in 2035, respectively. The

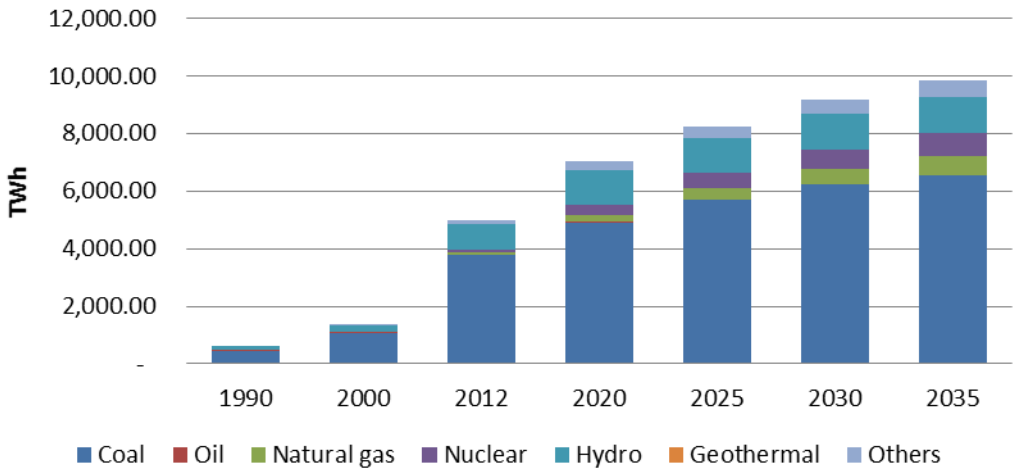
share of oil is projected to decrease slightly, whereas other sources of power generation are projected to increase. The fast development of photovoltaic power generation in China is a typical example, reflecting China's switching to clean power generation. China's thermal efficiency by fuel under BAU is projected to increase between 2012 and 2035, as presented in Figure 5-12.

Figure 5-10. CO_2 Emission from Energy Consumption, BAU and APS



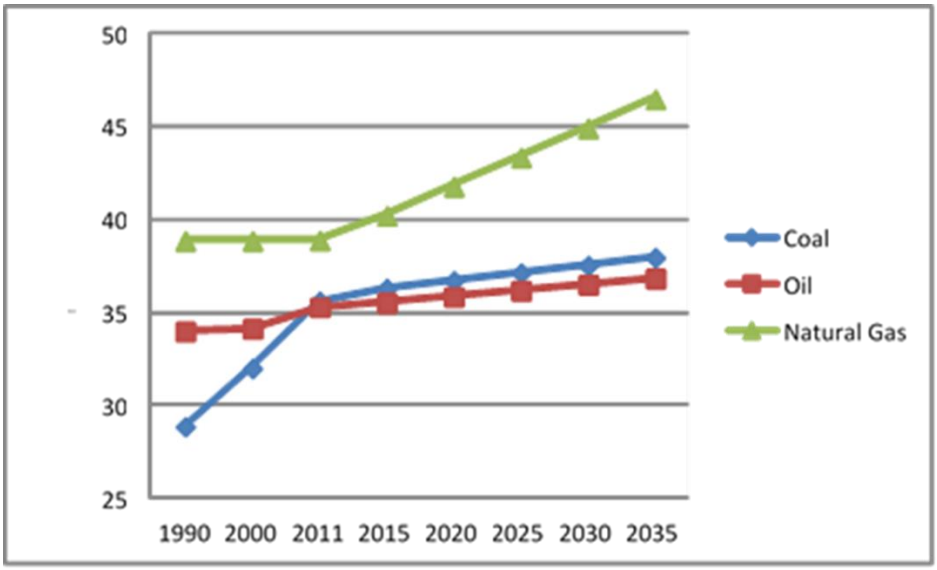
BAU = Business-as-Usual; APS = Alternative Policy Scenario.
Source: Author's calculation.

Figure 5- 11. Power Generation in BAU



Source: Author's calculation.

Figure 5-12. Thermal Efficiency by Fuel in BAU



BAU = Business-as-Usual.
Source: Author's calculation.

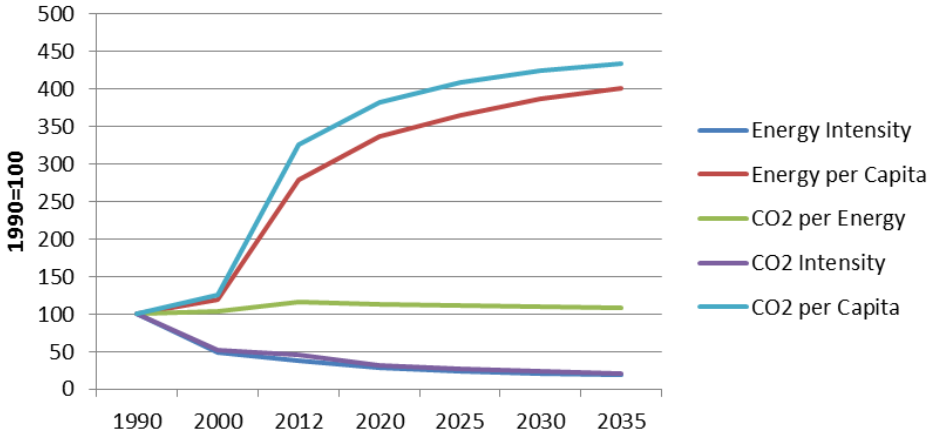
Alternative Policy Scenario (APS)

In the APS, total power generation will increase by 2.4 percent per year between 2012 and 2035. By 2035, total power generation output is projected to have reached 8,697.5 TWh. Except for coal-fired power, the annual growth rate per year between 2012 and 2035 of all fuel power types under APS are projected to grow faster than in the BAU scenario. In 2035, hydropower, geothermal power, and 'others', are projected to increase by an annual average of 2.0 percent, 4.0 percent, and 8.2 percent, respectively under APS between 2012 and 2035.

3.6. Energy Intensity and Other Energy Indicators

According to the assumed economic and population growth along with the projected energy information of China, energy intensity defined as TPES/GDP and energy per capita in the BAU scenario are illustrated in Figure 5-13. From 1990 to 2012, it shows that China's energy intensity saw a remarkable drop as a result of efforts on energy efficiency. In 2035, primary energy intensity in China is projected to drop to around 307.0 toe/million 2005 US$, or an annual average decrease of 3.1 percent per year. With the improvement of living standards in China, energy per capita under the BAU scenario is projected to reach 3.08 TOE per person in 2035. Compared with the energy intensity in BAU, primary energy intensity in the APS is projected to show a faster rate of decrease, of 3.8 percent, from 2012 to 2035.

Figure 5-13. Energy Indicators, BAU



BAU = Business-as-Usual.
Source: Author's calculation.

4. Implications and Policy Recommendations

As the world's largest developing country, it is paramount for China to eradicate poverty and improve quality of life. China is in a fast growth phase and its urbanisation rate is low. If China maintains fast GDP growth, its energy demand and CO_2 emissions will increase in the long run. In the past three decades, China has made great efforts on energy conservation and achieved great success. The latest effort was made during the 2014 APEC summits, when China and the United States issued a Joint Announcement on Climate Change. According to the announcement, China vowed CO_2 emissions would peak and the share of non-fossil fuels in primary energy consumption would increase to around 20 percent by 2030. Besides, Chinese metropolises such as Beijing and Shanghai have shown great ambition trying to limit energy-intensive and pollution-intensive industries, including steel and cement productions, to improve urban air quality.

Although China's energy demand and CO_2 emissions are expected to increase in the foreseeable future, energy intensity (energy demand per GDP) and emission intensity (CO_2 emission per GDP) would continue to decrease as the GDP growth rate stays relatively high. If sound energy efficiency and conservation policies are implemented, China could reduce its total primary energy consumption by around 13.5 percent and CO_2 emissions by about 21.4 percent by 2035. There is a great potential for energy saving in China, with around 50 percent of this achievable through structural change of the economy. The rapid development of the tertiary industry may also reduce China's energy demand.

Energy saving and energy efficiency improvement in industry will be important during the next 10 years. It is noteworthy that in 2014 coal consumption decreased for the first time since 2000, by 2.9 percent. Considering the fact that China has entered the 'new normal', in which the economic growth rate would be moderately high, and because Beijing has begun to make efforts in controlling air pollution, the relatively low growth rate of coal consumption may persist in the coming years. The scheduled closure of small and inefficient power plants, coal mines, and small energy-intensive plants in industries like

cement and steel could greatly improve China's energy intensity and carbon emission intensity. But in the long run it is more important to enhance energy efficiency in the residential, commercial, and transportation sectors for efficient energy saving. Moreover, the development of non-fossil and renewable energy resources promoted by future market demand is vital for an environment-friendly energy supply structure in future.

The Chinese government could also formulate more market-based measures to motivate enterprises to take action. Specifically, energy pricing reforms, energy taxes, and carbon taxes should be implemented gradually. China should also develop more energy efficiency standards and labelling to facilitate the development of an energy-efficient electrical appliances market. Reduction of energy subsidies would also help to incentivise more efficient use of energy.

There is also a need for a change in China's industrial structure (heavy to light industries or industry to services) and to accelerate the development of non-fossil energy including hydro, wind, and nuclear power. China also needs to urgently lengthen the lifecycle of buildings and infrastructure, which would reduce excessive consumption of energy intensive products such as steel and cement.